

Association of pre-operative factors with corneal thickness changes after crosslinking surgery

L. Haines,^{1*} O. Kralj,² S. Marschall,³ A. Gawish,⁴ P. Fieguth,⁴ N. Singal,⁵ H.F. Chew,⁵ D. Rootman,⁵ A. Slomovic,⁵ W. Hatch,⁵ K. Bizheva,^{1,2,4} L. Sorbara¹

¹School of Optometry & Vision Science, ²Dept. of Physics and Astronomy, ³Oculus, Wetzlar, Germany, ⁴Systems Design Engineering Dept., University of Waterloo, Waterloo, Ontario, Canada; ⁵Dept. of Ophthalmology and Vision Sciences, University of Toronto, Toronto, Ontario, Canada

*lhaines@uwaterloo.ca

Introduction

- Traditional treatments for keratoconus (KC) address patients' symptoms of poor vision, generally using specialty contact lenses.¹ Corneal crosslinking (CXL) surgery is a more recently developed treatment alternative that aims to reduce the progression of KC.² CXL can be combined with intracorneal ring segment (ICRS) insertion in an attempt to improve refractive outcomes.
- CXL surgery has proven to be a safe and effective treatment option for eyes with progressive KC in early and moderate stages.^{2,3} Some complications that have been reported after CXL include reduced visual acuity, corneal scarring and decreases in corneal thickness.^{2,3}
- Previous studies have shown that age, baseline thinnest pachymetry measurements, pre-operative visual acuity and baseline maximum keratometry (K) readings were associated with an increased risk of complications.^{4,5}
- Despite the increasingly large number of studies on CXL, there is little knowledge of its effect on the morphology of the cornea and its sublayers. This knowledge may lead to a better understanding of CXL complications and post-operative corneal shape changes. Pre-operative factors that can predict thickness changes in the cornea caused by CXL surgery could be used to help guide treatment decisions and maximize patient outcomes.

Purpose

The purpose of this study is to investigate whether age and baseline corneal topography measurements affect epithelial thickness (ET) or total corneal thickness (TCT) changes induced by the CXL procedure.

Methods

8 eyes with keratoconus from 8 subjects were imaged with a Scheimpflug topographer and a research grade swept-source optical coherence tomographer (SS-OCT) no more than one month prior to receiving CXL+ICRS surgery and again one year later. SS-OCT images were acquired using a research-grade SS-OCT system which provided 5 µm axial, ~15µm lateral resolution, and ~4 mm scanning depth in corneal tissue. Volumetric OCT images of the KC cornea were acquired at the speed of 100,000 A-scans/sec. The images were analyzed with a custom image processing algorithm that segmented the anterior and posterior surfaces of the cornea, as well as the posterior epithelial boundary. The pre-operative thicknesses of the total cornea and epithelial layer at the point of minimum total corneal thickness were acquired from the SS-OCT images using custom processing software. Regression analysis was performed to determine predictive factors for epithelial and total thickness changes one year after surgery. Statistical analysis was carried out with Origin 2013 and Excel 2013.

Results

Number of subjects/Eyes	8
Male:Female	5:3
Mean Age (years ± SD)	33.4 ± 9.9
Kmax (Dioptres ± SD)	59.0 ± 5.3
Mean Flat K (Dioptres ± SD)	48.4 ± 3.8
Mean Steep K (Dioptres ± SD)	53.5 ± 4.5
Min Corneal Thickness (µm ± SD)	456.2 ± 37.8
Epithelial Thickness (µm ± SD)	55.6 ± 5.0

Table 1. Baseline data for the keratoconic eyes prior to receiving CXL+ICRS surgery.

Figure 1:

Representative SS-OCT images for subject #4 at the pre-operative (A) and at the 12 month follow up (B) visits. The anterior and posterior corneal borders (yellow lines), as well as the posterior epithelial boundary (blue line), are segmented in B. The images displayed are shown before distortion correction.

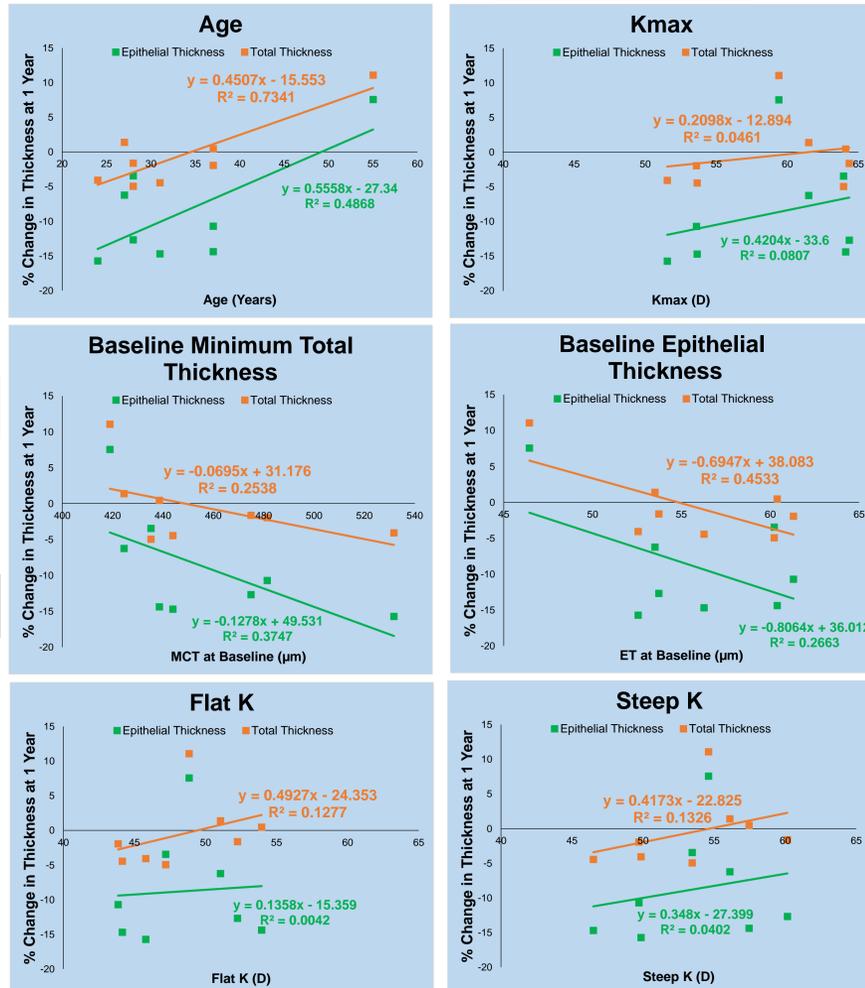
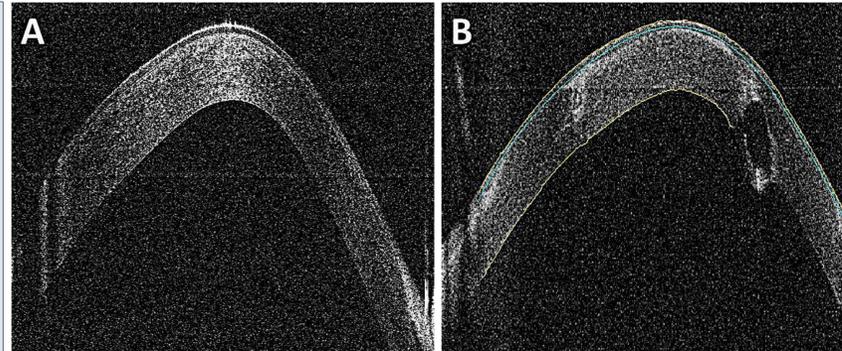


Figure 2: Scatterplots showing linear regression analysis for the percent changes in ET and TCT at one year plotted against the indicated pre-operative factor. The mean pre-operative ET (55.6±5.0µm) was significantly greater than the same measurement at one year (50.5±4.4µm; $p=0.01$). The mean pre-operative TCT (464.1±28.8µm) was not significantly different at the one year follow-up (453.0±31.6µm; $p=0.70$). Plotting of individual data shows the extent of corneal thickness changes that occurred in some eyes. Regression analysis demonstrates the strength of association between the pre-operative factors and corneal thickness changes, however, only age was significantly associated with ET ($R^2=0.49$, $p=0.05$) and TCT ($R^2=0.73$, $p=0.006$) changes at 1 year. * = Statistically significant ($p<0.05$).

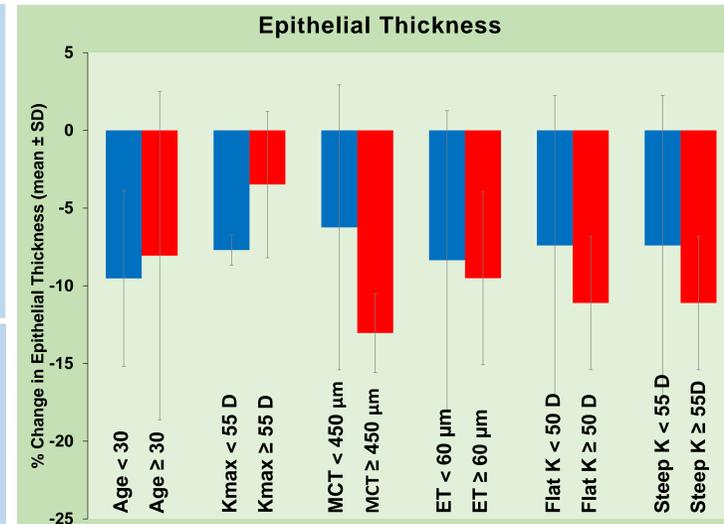


Figure 3: Relative changes in ET between baseline and one year after CXL + ICRS in the subcategories indicated. Differences between subcategories were not statistically significant ($p>0.05$).

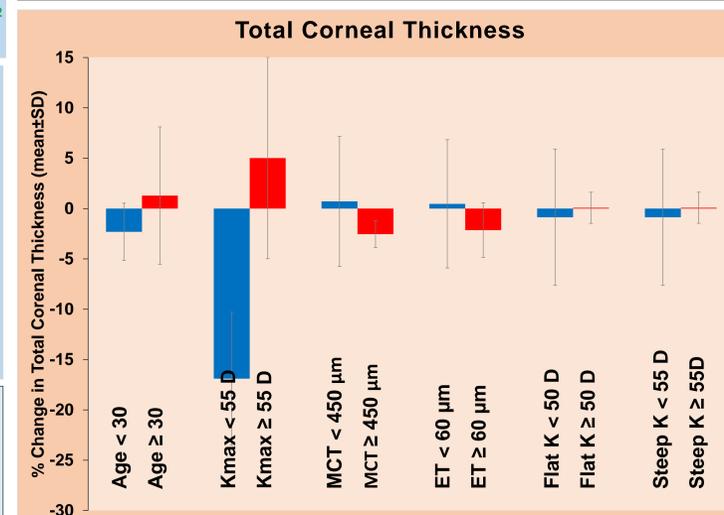


Figure 4: Relative changes in TCT between baseline and one year after CXL + ICRS in the subcategories indicated. Differences between subcategories were not statistically significant ($p>0.05$).

Discussion

- In this study, mean ET measurements showed a significant decrease one year after CXL+ICRS, but there was no significant change in average TCT values. Analysis of individual results demonstrate increases and decreases that were clinically significant, with changes of up to 15% for ET and 11% for TCT in some participants.
- Changes in the thickness of the cornea and its sublayers after CXL + ICRS can influence refractive outcomes and is monitored for potential complications. Large variations in individual results makes it difficult to predict treatment outcomes.
- Younger ages were significantly associated with decreases in ET and TCT one year after CXL + ICRS surgery. The other pre-operative factors Flat K, Steep K, maximum keratometry, pre-operative ET and thinnest pachymetry measurement were not significantly associated with changes in ET or TCT.
- This study did not find baseline thinnest pachymetry or Kmax to be related to corneal thickness changes. Visual acuity was not studied in this report. These pre-operative factors, in addition to age, have been shown to be associated with increased risk of complications in other studies.^{4,5}
- The sample size for this study was small and it is possible that larger sample sizes could reveal more significant relationships between corneal layer thicknesses and the pre-operative factors, especially baseline ET and Kmax which approached significance.

Conclusion

Mean corneal ET measurements were significantly less one year after CXL + ICRS surgery but TCT did not show a significant change. Both increases and decreases in individual thickness data were observed and only age was significantly associated with ET and TCT changes at one year. The other pre-operative factors studied were not significantly correlated with corneal thickness values.

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